

~~Surface Mounting Optoelectronic Component and Method For Producing Same~~

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 a The invention relates to a method for producing a surface mounting

optoelectronic component comprising a base body, an optoelectronic transmitter
 5 a and/or receiver that is arranged in ^a recess of the base body, and an optical device that
 occludes the recess, as well as to a surface mounting optoelectronic component.

In recent years, surface mounting technology (SMT) has increasingly
 supplanted the equipping of conductor carriers with wired components. The crucial
 advantage of SMT is an increase in packing density, which cannot be achieved by
 10 conventional insertion methods.

Due to the high packing density, which is desirable in many optical
 applications, SMT is particularly important in the field of optoelectronics. There are
 a already known optoelectronic components which are designed to be surface ^{mounted} ~~mounting~~
 in accordance with the SMT concept.
 15 a ^{European patent application No 02303364 here for} EP 0 230 336 4 describes a surface mounting optoelectronic component
 that comprises an annular housing, the upper opening of which is sealed by a ball lens,
 while the lower opening of the ring stands on a printed circuit board. Inside the
 a housing, a light-emitting semiconductor element is arranged between the ^{present} circuit board
 and the bottom vertex of the ball lens. The interior space of the ring housing, which is
 20 defined by the surface of the printed board and the ball lens, is filled with a
 transparent glue.

Another surface mounting optoelectronic component is illustrated in EP 0
 400 176. This component has a base body with a central depression in which an
 optically active semiconductor element is arranged. Above the base body, there is a
 25 lens, which is connected to the base body via a fixing mechanism such as a clamping
 peg.

"Siemens SMT-TOPLED für die Oberflächenmontage" (Frank Möllmer
 and Günter Waitl, *Siemens Components* 29 (1991), Vol. 4:147-149) teaches a light
 emitting diode (LED) which is provided for surface mounting. To produce this diode,

a continuously stamped conductor strip is coated with a thermally stable thermoplast, forming the housing frame. In the inner region of the housing frame, an optically active element is mounted on the conductor strip and electrically contacted to interconnects there. Next, the frame's interior region for guarding the active element
 5 against environmental influences is cast using a casting resin. A lens or similar optical device is not provided in this component.

The SMT opto-components described in the documents cited above have the unique attribute that first the whole component housing is produced by coating a conductor strip with a thermoplast material, and the opto-electronic transmitter and/or
 10 receiver is inserted into the thermoplast housing only after this is produced. The advantages of this method of production are that a very economical mass production at the belt (conductor strip) is possible, and low structural heights and standardized basic structural forms are easy to realize. Due to their low costs, these prehousing SMT opto-components, as they are called, are used above all in display arrays and the
 15 like.

SUMMARY OF THE INVENTION

It is the object of the present invention to set forth a method by which the emission characteristic of opto-electronic SMT components of the above type can be improved without raising the component costs unacceptably. The ^{present} invention is also
 20 directed to designing this type of optoelectronic SMT component with a well definable emission characteristic and simultaneously low component costs.

This object is achieved by a method with the features of claim 1 or claim 8 and by an optoelectronic component with the features of claim 18.

Following the production of the base body with the optoelectronic transmitter and/or receiver arranged in the recess, the recess of the base body is filled
 25 with a transparent hardenable casting compound, and the optical device is attached to the base body, said optical device being brought into contact with the casting compound in the region of the recess before the casting compound and/or the optical device (if this also comprises a casting compound) has completely hardened.

An essential aspect of the present invention is that the optical device is placed on the base body only after the recess is poured with casting compound. Because the optical device is placed onto the recess when the latter is already filled with casting compound, the optical device can be positioned on the base body
 5 extremely precisely and reproducibly, and this positioning remains essentially unaffected by subsequent steps such as curing or removal from the mold. This guarantees a high optical quality of the optoelectronic component with respect to the emission behavior or reception behavior, which is very important for applications in which an exact beam guidance and a high light yield are desirable. The ^{present} inventive
 10 optoelectronic components are thus superior to components in which the recess is filled from the reverse side given a previously mounted optical device.

The ^{present} inventive method can be applied particularly advantageously in the production of what are known as prehoused optoelectronic components. Here, the base body is produced first by coating a conductor strip with a thermoplast while the
 15 housing with the recess is simultaneously formed, and then the optoelectronic transmitter and/or receiver is assembled on a section of the conductor strip that resides in the recess.

In accordance with a first, particularly advantageous embodiment of the ^{present} inventive method, the optical device is placed on the as yet unhardened casting
 20 compound, and the casting compound is then cured.

In this case, the fill level of the casting compound can be selected such that casting compound does not escape over the edge of the recess when the optical device is placed on. It is then unnecessary to take measures to trap casting compound that may overflow.

25 It is also possible to exploit a fillet formation of the casting compound, which arises on the basis of its surface tension. In this case, an optical device is used whose shape in its region that contacts the casting compound is selected such that, even when the recess is filled to the edge with casting compound, said casting

compound does not overflow the edge of the recess when the optical device is placed on.

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5 The base body can also be provided with a ring channel that surrounds the recess before the optical device is placed on. In this case, casting compound that may overflow when the optical device is placed on is collected in the ring channel, ^{THUS} preventing it from running down on the exterior of the base body and hardening there, which would impair the manipulability of the component.

10 A particularly reproducible positioning of the optical device is achieved when, prior to the placement of the optical device, the base body is provided with seating elements that are arranged at the margin side relative to the recess. The seating elements can be formed integrated with the housing in the above described injection step for producing the base body for a prehoused optoelectronic component.

15 A Preferably, the optical device is placed from above onto the base body, or the seating elements that have been fashioned thereon, without pressure. The ^{Placement} depositing [sic] of the optical device then occurs by means of gravity alone.

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In an embodiment, ~~In a further advantageous variant of the method,~~ the optical device is first produced by means of a casting, pressing or injection procedure before the optical device is placed on, and then it is transported in bulk and placed onto a base body by automatic picking from the bulk material and automatic positioning over said base
20 body. The advantage of these measures is that the optical device is produced completely independently of the production of the base body, opening up the possibility to control the quality of the optical device effectively and distinctly and to eliminate spoilage. This makes it possible to produce components of the highest quality.

25 In a second particularly preferred embodiment of the inventive method, the optical device is formed in a casting process, and in the scope of this casting process it is placed onto the base body in the region of the recess and is cast out with the casting compound in the recess. Also, in this second embodiment of the inventive method, the recess of the base body is filled before the optical device is placed on in

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the scope of said pouring process, so that the advantages associated with this procedure are also manifest in this embodiment of the invention.

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In this second embodiment of the inventive ^{present} method for producing the optical device, one half of a casting mold is advantageously prepared first, and this half is filled with an additional casting compound. On the other hand, when the recess of the base body has been filled with casting compound, the casting compound is first hardened at least partially and is then wetted with casting compound. Next, the base body and the half of the casting mold which is filled with the additional casting compound are joined, under correct positioning, and in a following step the additional casting compound in the casting mold half is cured, whereby it is cast onto the casting compound in the recess of the base body. ^{therefor} ~~Lastly~~, the now finished optoelectronic component is ejected by removing the half of the casting mold from the base body with the optical device that has been cast on.

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Wetting can be accomplished by turning the base body about a horizontal axis and immersing it in casting compound at least on the surface, for example. Because of the at least partial hardening of the casting compound, none of the compound escapes during the turning process.

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The wetting of the surface of the casting compound prevents air bubbles from remaining in the casting compound in the subsequent casting on process.

The advantage of the described second embodiment of the inventive method is that it is particularly easy to realize and has a high potential for automatization, enabling a mass productions [sic] on an industrial scale.

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Further advantageous developments of the inventive method are laid out in the subclaims 2 to 7, or respectively, 9 to 17, and of the inventive component, in subclaims 19 and 20.

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The invention is exemplified below with reference to the drawings, in which are shown:

Figure 1 a perspective view of a base body with housing and conductor strip as used in the inventive method;

Figures 2A, 2B and 2C

Figure 2A, 2B, 2C the steps of preparing the base body, filling the recess of the base body, and placing the optical device onto the base body in accordance with a first embodiment of the present invention using the example of the base body illustrated in Figure 1;

5 Figure 3 *is* the optoelectronic component represented in Figure 2C, as produced in accordance with the first inventive embodiment, in a plan view.

Figure 4 *is* a schematic view explicating the production and transport of the optical device.

Figure 5 *shows* another optoelectronic component which is produced in accordance with the first embodiment of the inventive method;

Figure 6 *is* a plan view of the optoelectronic component illustrated in Figure 5; and

Figure 7 *is* a schematic representation explicating a second embodiment of the inventive method.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Figure 1 shows a base body 1, which is formed by coating a conductor strip 2 with a high-temperature thermoplast housing 3. The housing 3 advantageously has flat exterior surfaces, guaranteeing easy insertion. At the surface, a recess 4 is provided in the housing 3.

Figure 2A shows a sectional illustration of a base body 1 that is constructed essentially in accordance with Figure 1, the housing 3' differing from the housing 3 illustrated in Figure 1 only to the extent that the surface 5 of the housing 3' is provided with a ring groove 6 that surrounds the recess 4, which will be mentioned later. Figure 2A shows that sections 7,8 of the conductor strip 2 are surrounded by the thermoplast housing 3' and protrude with contact portions 9,10 into the recess 4 in the bottom region of said recess. A contact portion 9 is extended up to the central region of the recess 4.

The inner wall surfaces 13 of the housing 3 are constructed as oblique surfaces and form a reflector. By selecting a housing material with a high diffuse degree of reflection of approximately 90% or more, a high reflectivity of these surfaces 13 is generated.

Following the production of the conductor strip housing structure 2,3', a semiconductor chip 11 is mounted in the recess 4 of the housing 3'. In the representation in Figure 2A, this assembly step has already been performed. The semiconductor chip 11 is placed onto the extended contact portion 9 of the conductor strip 2 and electrically contacted to this. An additional electrical contacting occurs via a wire 12, which is led from the semiconductor chip 11 to the opposite contact portion 10 of the conductor strip 2. As semiconductor chip 11, a light-emitting diode or a photosensitive semiconductor element can be used, for example.

Following the assembly and contacting of the semiconductor chip 11, the recess 4 is filled with a free-flowing casting compound 14 in accordance with the illustration in Figure ^{2B}~~2A~~. The casting compound 14 can be a matter of an epoxy resin, for example. The casting compound 14 and the housing material are matched with respect to thermal properties in order to prevent thermal loads, such as may arise in the soldering of the component and in later use, from causing mechanical failures.

Due to the surface tension of the casting compound, its surface 15 is fashioned in the shape of a fillet; that is, it has a concave course.

The fill level of the casting compound 14 depends on the dimension of the fillet formation, the shape of the optical device that is placed onto the recess 4 in the next step (see Figure 2C), and also on whether measures have been taken at the housing ^{3''}~~3'~~ to trap casting compound ¹⁴~~14~~ that may overflow the edge, such as the surrounding ring groove 6 that is illustrated here.

Figure 2C illustrates the subsequent placement of an optical device onto the recess 4. In the example illustrated in Figure 2C, the optical device is realized in the form of a plane-convex convergent lens 16. On the side facing the recess 4, in the center region the convergent lens 16 has a flat base surface 17, which continues via a lead-in slope into a radially outlying annular seating surface 19. The base surface 17 is coplanar with the seating surface 19.

In the placing of the lens 16 onto the housing 3, which has been filled with casting compound ¹⁴~~14~~ in accordance with Figure 2B, the lens 16 is first positioned over

the recess 4 and aligned with it axially. Next, the lens 16 is lowered onto the thermoplast housing 3', whereby the lead-in slope 18 of the lens 16 and a top region of the inclined surface 13 of the inner wall of the reflector interact for self-centering. As a result, the achieved end position of the lens 16 relative to the housing 3' is largely independent of the preceding alignment step and is determined essentially by the dimensional stability of the lens¹⁶ and housing^{3'} production in the corresponding regions of the slope¹⁸ surface.

The lens 16 is placed on the housing 3' as follows: First, the lens's base surface 17 is brought into contact with the surface 15 of the casting compound 14. At this time, the seating surface 19 is not yet seated on the surface 5 of the housing 3'. The subsequent lowering of the lens 16 into the final position can be effectuated by the influence of gravity alone. This entails a surface-wide contact of the base surface 17 of the lens with casting compound 14 and, depending on the fill level of the recess 4 (Figure 2B), a displacing of casting compound 14 from the recess 4. Casting compound that overflows the edge of the housing^{3'} collects in the ring groove 6. The ring groove 6 thus prevents casting compound from flowing out down the housing's^{3'} outer wall, which would otherwise be possible. A certain overflow of casting compound¹⁴ into the ring groove 6 can thus be thoroughly desirable, since this favorably affects the closeness of the joint between the lens 16 and the housing 3'.

In a final step of production, the casting compound 14 is hardened in the component, for instance in the scope of a heat treatment.

Figure 3 shows a plan view of the optoelectronic component illustrated in Figure 2C. The oblique surfaces 13 of the wall of the recess 4 that form the reflector, and the semiconductor chip 11, are located under the lens 16 and are represented by broken lines. The optional ring groove 6 is not included in the illustration for reasons of simplicity.

The method detailed with the aid of Figures 2A to 2C can be carried out using lenses of various types and materials. It is essential, however, that in this

a embodiment of the inventive ^{present} method, the production of the lenses is already concluded before they are placed on the housing 3, 3'.

a Figure 4 details an example of the production of the plane-convex convergent lens 16 illustrated in Figure 2C by a transfer molding process that is carried out in a press tool 20. In this process, clear pressing compound is first pressed in the direction of the arrow 21 through a channel 22 of a heated half 23 of the tool into a ^{mold} ~~pressing mold~~ ³⁰ ~~30~~, which is defined by a mold surface 24 of the first half of the tool, a mold surface 26 of a second half 25 of the tool, which is situated adjacent the first half 23, and to the face surface 27 of a ring ejector 28 that has been displaceably accepted in the second tool half 25. The pressing compound is then formed by a pressing process into the lens 16, which is then pushed out of the press tool 20 by means of the ring ejector 28 in the direction of the arrow 29 in a hot state with a stable form. The lens 16 then drops into a lens collection container ³⁰ ~~30~~ as bulk material. The lens collection container 30 is connected to transport mechanisms, such as a shaker conveyor, funnels, and so on (which are not illustrated), via which the lens 16 is moved to an assembly unit (also not illustrated), by means of which it is placed on the housing 3 of the optoelectronic component in the described manner (see Figure 2C).

In the lens production method described in accordance with Figure 4, it has proven advantageous that only very low tolerances arise. As a result, on one hand, the spoilage is minimized, and on the other hand, the dimensional stability of the lens 16 favorably affects both the optical characteristics of the lens 16 and the reproducibility of the final position of the lens 16 in the housing 3, 3'.

A modification of the optoelectronic component illustrated in Figure 2C is shown in Figure 5. The component in Figure 5 differs from that in Figure 2C essentially in having a ball lens 16' of diameter R instead of the plane-convex lens 16.

The component illustrated in Figure 5 is produced by a method analogous to the steps represented in Figure 2A to Figure 2C. The self-centering of the ball lens 16 during placement onto the housing 3' is effectuated by its surface curvature. During placement of the lens 16', the ball portion 31 that protrudes into the recess 4 comes into

contact with the casting compound 14. By selecting the fill level and/or the radius R of the lens 16' appropriately, a precise correlation can be achieved between the course of the surface of the ball portion 31 in its inserted state and the convex course of the casting compound surface 15. In this case, in essence no casting compound is
 5 displaced during placement of the lens 16'. An additional advantage of the rounded ball portion 31 is that it guarantees that air bubbles cannot remain between the casting compound surface 15 and the lens 16' in the assembly process.

Figure 6 shows a plan view of the component illustrated in Figure 5 with ball lens 16'. This Figure⁶ shows that radial ridges are fashioned on the oblique inner
 10 wall surfaces 13 of the recess 4, which serve as seating surfaces for the ball lens 16'.

On one hand, the radial ridges 32 bring about a definite and stable three-point seating of the ball lens 16', which further enhances the reproducibility of the installation position of the ball lens 16' relative to the housing 3'. On the other hand, the radial ridges 32 create an annulus type free area between the inner surface 13 of the
 15 recess 4 and the ball portion 31, which area can serve as an accepting volume for displaced casting compound¹⁴ so that the casting compound¹⁴ can be prevented from overflowing the edge of the recess even in case of a marked displacement of casting compound.¹⁴

Radial ridges 32 or similar seating elements can also be provided given
 20 other lens shapes, and particularly given the plane-convex lens 16 used in accordance with Figure 2C.

Figure 7 details a second embodiment of the inventive^{present} method. The main difference between the two embodiments is that in the second embodiment the optical device is attached to the component housing 3 in a casting process.

Housings 3 that have been provided with an optical semiconductor chip 11
 25 (see Figure 1) are fed on a first strip 33 to a casting station 34, in which the recess 4 of the component housing 3 is cast. Next, a curing or at least partial curing of the casting compound is carried out by thermal effects³⁵. At 36 the strip 33 is turned 180°, and at 37

a the cast surface of the housing³₁ now directed downward, is immersed in casting resin for prewetting same.

The wetting of the hardened or cured-on casting compound can also be accomplished some other way. The wetting guarantees that the subsequent casting
5 process ensues without air bubbles.

A second strip 38 carries casting mold halves 39 which are provided for producing the optical device. To this end, the mold halves 39 are filled with a casting resin in a lens casting station 40. The first strip 33 with the housings 3 facing down, and the second strip 38 with the filled casting mold halves 39, are led together through
10 the gap between two hedgehog wheels 41, which are arranged axis-parallel, and are merged in the gap. The hedgehog wheels 41 are heated, so that a temperature of approx. 80°C prevails in the gap. After leaving the gap, the combination housing/ mold halves 3, 39 undergoes heat treatment 43 at approx. 150° C under the influence of a mechanical guidance 42. The effect of the heat treatment⁴³₄ is that casting material that
15 is respectively present in the casting mold halves 39-is poured onto the surface of the casting compound at the housing side and cures onto this surface. The two strips 33, 38 traverse the gap of a second pair of hedgehog wheels 44, which is likewise kept at a temperature of 80°C. The ejection of the component with the cast-on optical device 45 from the mold is accomplished at the output side of the second pair of hedgehog
20 wheels 44 by diverging the two strips 33 and 38.

The method illustrated in Figure 7 can be modified as follows:

Instead of on a strip, a predetermined number of n casting mold halves can be combined integrally in a pallet type group of casting molds. Following a corresponding pretreatment in accordance with Figure 7, the group of casting molds
25 which are filled with casting compound are led to the strip 33 from below such that each mold half of the group comes into contact with a housing 3 that is arranged on the strip 33. They can be held together by clamping, for instance. The strip 33 with the clamped-on casting mold group then undergoes a heat treatment 43 at approx. 150° C similarly to the double strip structure in Figure 7. Following successful curing, the

entire casting mold group is removed from the strip 33 in the scope of the ejection process.

The latter method employing a casting mold group has the advantage over the double-strip method illustrated in Figure 7 that the casting mold groups that are used can be reused some 200 to 300 times, while the casting mold halves 39 that are conveyed on the strip 38 generally must be replaced after a few usages. Besides this, greater positioning accuracy is achieved by the integral design and thus stable arrangement of the casting molds in the group, so that the optoelectronic components that are produced by this method generally satisfy higher quality requirements.

On the other hand, the double-strip method illustrated in Figure 7 has the advantage that it can be carried out very cost-effectively due to the high degree of automation.

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